Claims PTO

~~Allowed Claims for [illegible]~~

1. (Canceled)

(previously presented) 2. The plurality of abrasive particles according to claim 41 wherein said fused, crystalline abrasive particles comprise at least 50 percent by volume, based on the total metal oxide volume of the respective particle, of said eutectic material.

(11) 3. The plurality of abrasive particles according to claim 2 comprising, on a theoretical oxide basis, at least 40 percent by weight $Al_2O_3$, based on the total metal oxide content of the respective particle.

(11) 4. The plurality of abrasive particles according to claim 3, wherein said fused, crystalline abrasive particles further comprise primary crystals of $Al_2O_3$.

(11) 5. The plurality of abrasive particles according to claim 3, wherein said fused, crystalline abrasive particles comprise colonies of said eutectic, and wherein said colonies have an average size of less than 100 micrometers.

(11) 6. The plurality of abrasive particles according to claim 5, wherein said colonies have an average size of less than 50 micrometers.

(11) 7. The plurality of abrasive particles according to claim 3, wherein said fused, crystalline abrasive particles comprise colonies of said eutectic, and wherein crystals making up said colonies are, on average, up to 10 micrometers in size.

(11) 8. The plurality of abrasive particles according to claim 7, wherein said crystals are, on average, up to 1 micrometer in size.

(11) 9. The plurality of abrasive particles according to claim 3, wherein said fused, crystalline abrasive particles further comprise comprises at least one of crystalline rare earth oxide or crystalline complex $Al_2O_3$·rare earth oxide.

(11)

10. The plurality of abrasive particles according to claim 3, wherein said fused, crystalline abrasive particles further comprise at least one of crystalline BaO, CaO, $Cr_2O_3$, CoO, $Fe_2O_3$, $HfO_2$, $Li_2O$, MgO, MnO, NiO, $SiO_2$, $TiO_2$, $Na_2O$, $Sc_2O_3$, SrO, $V_2O_3$, ZnO, or complex $Al_2O_3$·metal oxide thereof.

(11)

11. The plurality of abrasive particles according to claim 3, wherein said fused, crystalline abrasive particles have an average microhardness of at least 13 GPa.

(11)

12. The plurality of abrasive particles according to claim 3, wherein said complex $Al_2O_3$·$Y_2O_3$ further comprises cations selected from the group consisting of Cr, Ti, Sc, Fe, Mg, Ca, Si, Co, Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Th, Tm, Yb, and combinations thereof.

(11)

13. A plurality of abrasive particles having a specified nominal grade, said plurality of abrasive particle having a particle size distribution ranging from fine to coarse, wherein at least a portion of said abrasive particles is a plurality of fused, crystalline abrasive particles, said fused abrasive particles comprising at least 20 percent by volume, based on the total metal oxide volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline $ZrO_2$ and

(b) at least two of:

(i) crystalline $Al_2O_3$,

(ii) first crystalline complex $Al_2O_3$·$Y_2O_3$, or

(iii) second, different, crystalline complex $Al_2O_3$·$Y_2O_3$, wherein said fused, crystalline abrasive particles comprise at least 50 percent by volume, based on the total metal oxide volume of the respective particle, of said eutectic material, wherein the abrasive particles comprising, on a theoretical oxide basis, at least 40 percent by weight $Al_2O_3$, based on the total metal oxide content of the respective particle, and wherein a portion of said complex $Al_2O_3$·$Y_2O_3$ Al cations are substituted with at least one cation selected from the following cations: Cr, Ti, Sc, Fe, Mg, Ca, Si, and Co.

(11)

14. A plurality of abrasive particles having a specified nominal grade, said plurality of abrasive particle having a particle size distribution ranging from fine to coarse, wherein at least a portion of said abrasive particles is a plurality of fused, crystalline abrasive particles, said fused abrasive particles comprising at least 20 percent by volume, based on the total metal oxide volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline $ZrO_2$ and

(b) at least two of:

(i) crystalline $Al_2O_3$,

(ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or

(iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$, wherein said fused, crystalline abrasive particles comprise at least 50 percent by volume, based on the total metal oxide volume of the respective particle, of said eutectic material, wherein the abrasive particles comprising, on a theoretical oxide basis, at least 40 percent by weight $Al_2O_3$, based on the total metal oxide content of the respective particle, and wherein a portion of said complex $Al_2O_3 \cdot Y_2O_3$ Y cations are substituted with at least one cation selected from the following cations: Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Th, Tm, and Yb.

(11)

15. A plurality of abrasive particles having a specified nominal grade, said plurality of abrasive particle having a particle size distribution ranging from fine to coarse, wherein at least a portion of said abrasive particles is a plurality of fused, crystalline abrasive particles, said fused abrasive particles comprising at least 20 percent by volume, based on the total metal oxide volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline $ZrO_2$ and

(b) at least two of:

(i) crystalline $Al_2O_3$,

(ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or

(iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$, wherein said fused, crystalline abrasive particles comprise at least 50 percent by volume, based on the total metal oxide volume of the respective particle, of said eutectic material, wherein the abrasive particles comprising, on a theoretical oxide basis, at least 40 percent by weight $Al_2O_3$, based on the total metal oxide content of the respective particle, and wherein a portion of said complex $Al_2O_3 \cdot Y_2O_3$ Y cations are substituted with at least one cation selected from the following cations: Fe, Ti, Mn, V, Cr, Co, Ni, Cu, Mg, Ca, and Sr.

(11)

16. The plurality of abrasive particles according to claim 2, said fused, crystalline abrasive particles further comprise primary crystals of $Y_3Al_5O_{12}$.

(11)

17. The plurality of abrasive particles according to claim 41, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) crystalline $Al_2O_3$, and (c) crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11)

18. The plurality of abrasive particles according to claim 17 comprising at least 50 percent by volume, based on the total metal oxide volume of the respective particle, of said eutectic material.

(11)

19. The plurality of abrasive particles according to claim 18 comprising, on a theoretical oxide basis, at least 40 percent by weight $Al_2O_3$, based on the total metal oxide content the respective particle.

(11)

20. The plurality of abrasive particles according to claim 19, wherein said fused, crystalline abrasive particles comprise colonies of said eutectic, and wherein crystals making up said colonies are, on average, up to 10 micrometers in size.

(11)

21. The plurality of abrasive particles according to claim 19, wherein said fused, crystalline abrasive particles further comprise at least one of crystalline BaO, CaO, $Cr_2O_3$, CoO, $Fe_2O_3$, $HfO_2$, $Li_2O$, MgO, MnO, NiO, $SiO_2$, $TiO_2$, $Na_2O$, SrO, $Sc_2O_3$, $V_2O_3$, ZnO, or complex $Al_2O_3$·metal oxide thereof.

(11)

22. The plurality of abrasive particles according to claim 19, wherein said fused, crystalline abrasive particles have an average microhardness of at least 13 GPa.

(11)

23. The plurality of abrasive particles according to claim 2, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) first crystalline complex $Al_2O_3$·$Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3$·$Y_2O_3$.

(11)

24. The plurality of abrasive particles according to claim 23 comprising at least 50 percent by volume, based on the total metal oxide volume of said particle, of said eutectic material.

(11)

25. The plurality of abrasive particles according to claim 24 comprising, on a theoretical oxide basis, at least 40 percent by weight $Al_2O_3$, based on the total metal oxide content said particle.

(11)

26. The plurality of abrasive particles according to claim 25, wherein said fused, crystalline abrasive particles comprise colonies of said eutectic, and wherein crystals making up said colonies are, on average, up to 10 micrometers in size.

(11)

27. The plurality of abrasive particles according to claim 25, wherein said fused, crystalline particles further comprise at least one of crystalline BaO, CaO, $Cr_2O_3$, CoO, $Fe_2O_3$, $HfO_2$, $Li_2O$, MgO, MnO, NiO, $SiO_2$, $TiO_2$, $Na_2O$, SrO, $Sc_2O_3$, $V_2O_3$, ZnO, or complex $Al_2O_3$·metal oxide thereof.

(11)

28. The plurality of abrasive particles according to claim 25, wherein said fused, crystalline abrasive particles have an average microhardness of at least 13 GPa.

29. (canceled)

(previously presented) 30. The plurality of abrasive particles according to claim 44 comprising at least 50 percent by volume, based on the total metal oxide volume of the respective particle, of said eutectic material.

(11) 31. The plurality of abrasive particles according to claim 30 comprising, on a theoretical oxide basis, at least 40 percent by weight $Al_2O_3$, based on the total metal oxide content the respective particle.

(11) 32. The plurality of abrasive particles according to claim 30, wherein said fused, crystalline abrasive particles comprise colonies of said eutectic, and wherein crystals making up said colonies are, on average, up to 10 micrometers in size.

(11) 33. The plurality of abrasive particles according to claim 30, wherein said fused, crystalline abrasive particles further comprise at least one of crystalline BaO, CaO, $Cr_2O_3$, CoO, $Fe_2O_3$, $HfO_2$, $Li_2O$, MgO, MnO, NiO, $SiO_2$, $TiO_2$, $Na_2O$, SrO, $Sc_2O_3$, $V_2O_3$, ZnO, or complex $Al_2O_3$·metal oxide thereof.

(11) 34. The plurality of abrasive particles according to claim 30, wherein said fused, crystalline abrasive particles have an average microhardness of at least 13 GPa.

(11) 35. The plurality of abrasive particles according to claim 30 wherein at least a majority by weight of said crystalline $ZrO_2$ is cubic $ZrO_2$.

36-40. (canceled)

(previously presented) 41. A plurality of abrasive particles having a specified nominal grade, said plurality of abrasive particle having a particle size distribution ranging from fine to coarse, wherein at least a portion of said abrasive particles is a plurality of fused, crystalline abrasive particles, said fused abrasive particles comprising at least 20 percent by volume, based on the total metal oxide volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline $ZrO_2$ and

(b) at least two of:

(i) crystalline $Al_2O_3$,

(ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or

(iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

42-43 (Canceled)

(previously presented) 44. A plurality of abrasive particles having a specified nominal grade, said plurality of abrasive particle having a particle size distribution ranging from fine to coarse, wherein at least a portion of said abrasive particles is a plurality of fused, crystalline abrasive particles, said fused abrasive particles comprising at least 20 percent by volume, based on the total metal oxide volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline complex $Al_2O_3 \cdot Y_2O_3$ and

(b) crystalline $ZrO_2$.

(11) 45. The plurality of abrasive particles according to claim 44 wherein at least a majority by weight of said crystalline $ZrO_2$ is cubic $ZrO_2$.

(12) 46. A method for making fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least (a) crystalline $ZrO_2$ and (b) at least two of (i) crystalline $Al_2O_3$, (ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or (iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$, said method comprising:

melting at least one $Al_2O_3$ source, at least one $Y_2O_3$ source, and at least one $ZrO_2$ source to provide a melt;

converting the melt to said fused, crystalline abrasive particles; and

grading said fused, crystalline abrasive particles to provide a plurality of abrasive particles having a specified nominal grade, said plurality of abrasive particles having a particle size distribution ranging from fine to coarse, wherein at least a portion of said plurality of abrasive particles is a plurality of said fused, crystalline abrasive particles.

(11)

47. The method according to claim 46, wherein converting includes:

cooling the melt to provide a solidified material; and

crushing the solidified material to provide said fused, crystalline abrasive particles.

(11)

48. The method according to claim 47, wherein cooling the melt includes cooling the melt with metallic plates.

(11)

49. The method according to claim 47, wherein cooling the melt includes cooling the melt with metallic balls.

(11)

50. The method according to claim 46, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$ (b) crystalline $Al_2O_3$, and crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11)

51. The method according to claim 46, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11)

52. A method for making fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least (a) crystalline complex $Al_2O_3 \cdot Y_2O_3$ and (b) crystalline $ZrO_2$, said method comprising:

melting at least one $Al_2O_3$ source, at least one $Y_2O_3$ source, and at least one $ZrO_2$ source to provide a melt;

converting the melt to said fused, crystalline abrasive particles; and

grading said fused, crystalline abrasive particles to provide a plurality of abrasive particles having a specified nominal grade, said plurality of abrasive particles having a particle size distribution ranging from fine to coarse, wherein at least a portion of said plurality of abrasive particles is a plurality of said fused, crystalline abrasive particles.

(11) 53. An abrasive article comprising a binder and a plurality of abrasive particles, wherein at least a portion of said abrasive particles are fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline $ZrO_2$ and

(b) at least two of:

(i) crystalline $Al_2O_3$,

(ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or

(iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11) 54. The abrasive article according to claim 53, wherein said article is a coated abrasive article, and further comprises a backing.

(11) 55. The abrasive article according to claim 53, wherein said article is a bonded abrasive article.

(11) 56. The abrasive article according to claim 53, wherein said article is a nonwoven abrasive article, and further comprises a nonwoven web.

(11) 57. The abrasive article according to claim 53, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) crystalline $Al_2O_3$, and (c) crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11) 58. The abrasive article according to claim 53, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11)

59. An abrasive article comprising a binder and a plurality of abrasive particles, wherein at least a portion of said abrasive particles are fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline complex $Al_2O_3 \cdot Y_2O_3$ and

(b) crystalline $ZrO_2$.

(11)

60. The abrasive article according to claim 59 wherein at least a majority by weight of said crystalline $ZrO_2$ is cubic $ZrO_2$.

(11)

61. A vitrified bonded abrasive article comprising a plurality of abrasive particles bonded together via vitrified bonding material, wherein at least a portion of said plurality of abrasive particles are fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline $ZrO_2$ and

(b) at least two of:

(i) crystalline $Al_2O_3$,

(ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or

(iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11)

62. The vitrified bonded abrasive article according to claim 61, wherein said vitrified bonding material comprises silica, alumina, and boria.

(11)

63. The vitrified bonded abrasive article according to claim 62, wherein said vitrified bonding material comprises at least 10 percent by weight of said alumina.

(11)

64. The vitrified bonded abrasive article according to claim 63, wherein said vitrified bonding material comprises at least 10 percent by weight of said boria.

65. The vitrified bonded abrasive article according to claim 61, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) crystalline $Al_2O_3$, and (c) crystalline complex $Al_2O_3 \cdot Y_2O_3$.

66. The vitrified bonded abrasive article according to claim 61, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

67. A vitrified bonded abrasive article comprising a plurality of abrasive particles bonded together via vitrified bonding material, wherein at least a portion of said plurality of abrasive particles are fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline complex $Al_2O_3 \cdot Y_2O_3$ and

(b) crystalline $ZrO_2$.

68. The vitrified bonded abrasive article according to claim 67 wherein at least a majority by weight of said crystalline $ZrO_2$ is cubic $ZrO_2$.

69. A method of abrading a surface, said method comprising:

providing an abrasive article comprising a binder and a plurality of abrasive particles, wherein at least a portion of said abrasive particles are fused, crystalline abrasive particle comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least (a) crystalline $ZrO_2$ and (b) at least two of (i) crystalline $Al_2O_3$, (ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or (iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$;

contacting at least one of said fused, crystalline abrasive particles with a surface of a workpiece; and

moving at least one of the contacted fused abrasive particle or said surface relative to the other to abrade at least a portion of said surface with the contacted fused abrasive particle.

to the other to abrade at least a portion of said surface with said fused abrasive particle.

(11) 70. The method according to claim 69, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) crystalline $Al_2O_3$, and (c) crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11) 71. The method according to claim 69, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11) 72. A method of abrading a surface, said method comprising:

providing an abrasive article comprising a binder and a plurality of abrasive particles, wherein at least a portion of said abrasive particles are fused, crystalline abrasive particle comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least (a) crystalline complex $Al_2O_3 \cdot Y_2O_3$ and (b) crystalline $ZrO_2$;

contacting at least one of said fused, crystalline abrasive particles with a surface of a workpiece; and

moving at least one of the contacted fused abrasive particle or said surface relative to the other to abrade at least a portion of said surface with the contacted fused abrasive particle.

(11) 73. The method according to claim 72, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) crystalline $Al_2O_3$, and (c) crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11) 74. The method according to claim 72, wherein said eutectic is eutectic of at least (a) crystalline $ZrO_2$, (b) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

(11) 75. The plurality of abrasive particles according to claim 41 wherein said specified nominal grade is selected from the group consisting of ANSI 16, ANSI 24, ANSI 36, ANSI 40, ANSI 50, ANSI 60, ANSI 80, ANSI 100, ANSI 120, ANSI 150, ANSI 180, ANSI 220, ANSI 240, ANSI 280, ANSI 320, ANSI 360, ANSI 400, and ANSI 600.

(11) 76. The plurality of abrasive particles according to claim 41 wherein said specified nominal grade is selected from the group consisting of P16, P24, P36, P40, P50, P60, P80, P100, P120, P150, P180, P220, P320, P400, P500, P600, P800, P1000, and P1200.

(11) 77. The plurality of abrasive particles according to claim 41 wherein said specified nominal grade is selected from the group consisting of JIS16, JIS24, JIS36, JIS46, JIS54, JIS60, JIS80, JIS100, JIS150, JIS180, JIS220, JIS240, JIS280, JIS320, JIS360, JIS400, JIS600, JIS800, JIS1000, JIS1500, JIS2500, JIS4000, JIS6000, JIS8000, and JIS10,000.

(11) 78. The plurality of abrasive particles according to claim 44 wherein said specified nominal grade is selected from the group consisting of ANSI 16, ANSI 24, ANSI 36, ANSI 40, ANSI 50, ANSI 60, ANSI 80, ANSI 100, ANSI 120, ANSI 150, ANSI 180, ANSI 220, ANSI 240, ANSI 280, ANSI 320, ANSI 360, ANSI 400, and ANSI 600.

(11) 79. The plurality of abrasive particles according to claim 44 wherein said specified nominal grade is selected from the group consisting of P16, P24, P36, P40, P50, P60, P80, P100, P120, P150, P180, P220, P320, P400, P500, P600, P800, P1000, and P1200.

80. The plurality of abrasive particles according to claim 44 wherein said specified nominal grade is selected from the group consisting of JIS16, JIS24, JIS36, JIS46, JIS54, JIS60, JIS80, JIS100, JIS150, JIS180, JIS220, JIS240, JIS280, JIS320, JIS360, JIS400, JIS600, JIS800, JIS1000, JIS1500, JIS2500, JIS4000, JIS6000, JIS8000, and JIS10,000.

81. The method according to claim 69 wherein said surface is selected from the group of metals consisting of aluminum, carbon steel, mild steel tool steel, stainless steel, hardened steel, and titanium.

82. The method according to claim 69wherein said surface is aluminum.

83. The method according to claim 69 wherein said surface is carbon steel.

84. The method according to claim 69 wherein said surface is mild steel.

85. The method according to claim 69 wherein said surface is tool steel.

86. The method according to claim 69 wherein said surface is stainless steel.

87. The method according to claim 69 wherein said surface is titanium.

88. The method according to claim 69 wherein said surface is wood.

89. The method according to claim 72 wherein said surface is selected from the group of metals consisting of aluminum, carbon steel, mild steel tool steel, stainless steel, hardened steel, and titanium.